CLAIMS

What is claimed is:

Claim 1 - A system for high volume print-forming comprising in combination:

a bed having a plurality of alignment locations;

at least two of said alignment locations positioned at different heights relative to each other;

a plurality of substrate blocks, each substrate block including a substantially planar exposed surface and adapted to be positioned on one of said alignment locations of said bed and to move between said alignment locations while supporting upon said exposed surface a structure being print formed; and

a printer located adjacent said exposed surfaces of said substrate blocks and adapted to print material down toward said substrate blocks and upon the structures being print formed upon said substrate blocks.

Claim 2 - The system of Claim 1 wherein at least two of said alignment locations of said bed are spaced laterally from a third alignment location in two non-parallel directions from each other, such that said alignment locations are not arrayed linearly.

Claim 3 - The system of Claim 1 wherein said alignment locations include regions on a sloping surface of said bed facing said substrate blocks.

Claim 4 - The system of Claim 1 wherein said alignment locations include planar steps.

Claim 5 - The system of Claim 4 wherein said system includes a means for moving said substrate blocks between said steps.

Claim 6 - The system of Claim 5 wherein said bed includes a rectangular array of said steps arranged in multiple rows and columns, and wherein said substrate block moving means includes a shuffler adapted to slide all of said substrate blocks laterally a distance similar to a width of said substrate blocks, and a lifter adapted to grab a column of end substrate blocks most distant from said shuffler with one of said end substrate

blocks removed with a completed structure and the remainder of said end substrate blocks replaced on an end of said bed adjacent said shuffler, but down one row from a previous row for each of said end substrate blocks.

Claim 7 - The system of Claim 5 wherein said moving means is adapted to move said substrate blocks in a pattern along a plurality of linear rows and linear columns of said steps in said bed with each moving cycle involving shifting along a common row to an adjacent column except that end substrate blocks at the end of each row in the direction of movement is moved to the opposite end of the bed and down one row, and with said end substrate block at an end of the last row being removed with a completed structure thereon, and with a new substrate block supplied at a first row of the bed ready to begin print-forming thereon.

Claim 8 - The system of Claim 5 wherein said moving means follows a pattern of substrate block movement which includes moving said substrate blocks upon a rectangular array of multiple columns and rows of steps with adjacent rows of substrate blocks moving in opposite directions, and with substrate blocks at the end of each row moving to an adjacent row within a common column, and with one substrate block in a last row having a completed structure thereon removed, and with one substrate block in a first row newly provided for beginning the print-forming process thereon.

Claim 9 - The system of Claim 8 wherein a curb is provided, said curb adapted to guide said substrate blocks at the ends of rows to an adjacent row within the same column without rotation.

Claim 10 - The system of Claim 8 wherein a curb is provided, said curb adapted to move said substrate blocks at the ends of rows to an adjacent row within the same column with a 90° rotation thereof.

Claim 11 - The system of Claim 8 wherein a curb is provided along with a rotating disk, said curb and rotating disk adapted to rotate said substrate blocks 180° while transitioning said substrate blocks to an adjacent row within the same column.

Claim 12 - The system of Claim 5 wherein said substrate block moving means follows a pattern which spirals between a perimeter of said bed and a center of said bed.

Claim 13 - The system of Claim 5 wherein said bed includes a plurality of said steps spaced along a line with said steps being progressively lower, said substrate block moving means adapted to follow a linear path from higher steps of said bed to lower steps of said bed.

Claim 14 - The system of Claim 13 wherein said bed includes at least two rows of said steps within a common column perpendicular to said rows being of similar height.

Claim 15 - The system of Claim 1 wherein said system further includes a plurality of substrate block holders each adapted to hold one of said substrate blocks precisely upon one of said alignment locations of said bed during printing by said printer.

Claim 16 - The system of Claim 15 wherein said substrate block holders include a source of vacuum within said bed with vacuum ports extending up through said alignment locations in said bed to hold said substrate blocks down upon said alignment locations of said bed in fixed position during printing.

Claim 17 - The system of Claim 16 wherein said substrate block holders include alignment structures upon said substrate blocks having a contour complemental with structures within said bed, such that said substrate blocks are precisely aligned upon said alignment locations of said bed when said source of vacuum applies a vacuum force drawing said substrate blocks down upon said bed.

Claim 18 - The system of Claim 17 wherein said alignment structures include alignment pins and alignment holes of complemental form in said substrate blocks and in said bed, with said pins received within said holes when said substrate blocks are properly aligned upon said bed.

Claim 19 - The system of Claim 15 wherein said plurality of substrate block holders include complemental magnetic structures between said substrate blocks and said alignment locations in said bed such that magnetic forces between the substrate blocks

and said bed draw said substrate blocks to a precise position required upon said bed.

Claim 20 - The system of Claim 15 wherein said plurality of substrate block holders include mechanical clamps between the bed alignment locations and the substrate blocks, said clamps adapted to mechanically hold said substrate blocks precisely where required upon each alignment location of said bed.

Claim 21 - The system of Claim 1 wherein said printer includes a plurality of print spaces overlying said alignment locations of said bed, said spaces adapted to print material in patterns corresponding with a geometry of different layers of a common structure to be formed.

Claim 22 - The system of Claim 21 wherein said printer is a screen printer with a screen containing said spaces.

Claim 23 - The system of Claim 22 wherein said screen is sized at least as large as said bed, said alignment locations on said bed including steps, wherein a number of said spaces contained within said screen is equal to a number of said steps in said bed, wherein each said space on said screen has a pattern corresponding with a geometry of a separate layer of the structure to be formed, wherein each said step of said bed has a different height, and wherein a height differential between said steps of said bed is uniform and equal to a height of each layer of print material being printed by said printer.

Claim 24 - The system of Claim 23 wherein said screen printer includes a positive screen and a negative screen, said positive screen adapted to be used with positive ink material and said negative screen adapted to be used with negative ink material, said positive screen and said negative screen together providing a substantially complete layer for the structure to be formed, with later removal of the negative ink material from all of the layers resulting in the finished structure formed of the positive ink material.

Claim 25 - The system of Claim 24 wherein said screen printer includes a means to cure the materials deposited by said positive printing station and said negative printing

station.

Claim 26 - The system of Claim 25 wherein a negative remover is provided downstream from said printer, said negative remover adapted to remove the negative ink material from the structure being formed after it moves away from said printer.

Claim 27 - The system of Claim 25 wherein a combined negative remover and debinder is provided downstream from said printer, said combined negative remover and debinder adapted to both remove the negative ink material and the binder within the positive ink material.

Claim 28 - The system of Claim 26 wherein said system includes a debinder downstream from said negative remover, said debinder adapted to remove a binder contained within the positive ink material applied by said printer, and wherein said machine includes a densifier downstream from said debinder, said densifier adapted to densify the positive ink material applied by said printer.

Claim 29 - The system of Claim 1 wherein said substrate blocks include regular substrate blocks and starter substrate blocks, said starter substrate blocks having a greater height than said regular substrate blocks.

Claim 30 - The system of Claim 29 wherein said regular substrate blocks each have a common height.

Claim 31 - The system of Claim 29 wherein said starter substrate blocks each have a different height with a height differential equal to a height of each material print layer.

Claim 32 - A high volume print-forming machine, comprising in combination:

a bed having a plurality of alignment locations;

at least three of said alignment locations positioned at different heights relative to each other;

at least two of said alignment locations spaced laterally from a third said alignment location in two non-parallel directions from each other, such that said alignment locations are not arrayed linearly; and

a printer located above said bed and adapted to print material down toward said bed.

Claim 33 - The machine of Claim 32 wherein said printer includes a plurality of print spaces overlying said alignment locations of said bed, said spaces adapted to print material in patterns corresponding with a geometry of different layers of a common structure to be formed.

Claim 34 - The machine of Claim 33 wherein said printer is a screen printer with a screen containing said spaces.

Claim 35 - The machine of Claim 34 wherein said screen is sized at least as large as said bed.

Claim 36 - The machine of Claim 34 wherein a number of said spaces contained within said screen is equal to a number of said alignment locations in said bed.

Claim 37 - The machine of Claim 34 wherein each said space on said screen has a pattern corresponding with a geometry of a separate layer of the structure to be formed, and wherein each said alignment location of said bed includes a step having a different height.

Claim 38 - The machine of Claim 37 wherein a height differential between said steps of said bed is uniform and equal to a height of each layer of print material being printed by said printer.

Claim 39 - The machine of Claim 34 wherein said screen printer includes a positive screen and a negative screen, said positive screen adapted to be used with positive ink material and said negative screen adapted to be used with negative ink material, said positive screen and said negative screen together providing a substantially complete layer for the structure to be formed, with later removal of the negative ink material from all of the layers resulting in the finished structure formed of the positive ink material.

Claim 40 - The machine of Claim 39 wherein said screen printer includes a means to cure the materials deposited by said positive printing station and said negative printing

station.

Claim 41 - The machine of Claim 40 wherein a negative remover is provided downstream from said printer, said negative remover adapted to remove the negative ink material from the structure being formed after it moves away from said printer.

Claim 42 - The machine of Claim 41 wherein said negative remover is also adapted to remove a binder contained within the positive ink material.

Claim 43 - The machine of Claim 41 wherein said negative remover is adapted to remove the negative ink material through a process taken from the group of negative removal processes including heating, liquid washing, evaporation, chemical dissolving, and ultrasonic cleansing.

Claim 44 - The machine of Claim 41 wherein said machine includes a debinder downstream from said negative remover, said debinder adapted to remove a binder contained within the positive ink material applied by said printer.

Claim 45 - The machine of Claim 44 wherein said debinder is adapted to remove said binder through a process taken from the group of debinder processes including heating, liquid washing, evaporation, chemical dissolving, and ultrasonic cleansing.

Claim 46 - The machine of Claim 44 wherein said machine includes a densifier downstream from said debinder, said densifier adapted to densify the positive ink material applied by said printer.

Claim 47 - The machine of Claim 46 wherein said densifier is adapted to densify the positive ink material forming the structure being formed through a process taken from the group of densifier processes including heating, liquid washing, evaporation, chemical dissolving, ultrasonic cleansing, isostatic pressing and heating in atmospheres of special fluids in a vacuum.

Claim 48 - The machine of Claim 32 wherein a plurality of substrate blocks are provided with each substrate block adapted to be positioned on one of said alignment locations of said bed and to move between said alignment locations while supporting a

structure being print formed thereon.

Claim 49 - The machine of Claim 48 wherein said machine further includes a plurality of substrate block holders each adapted to hold one of said substrate blocks precisely upon one of said alignment locations of said bed during printing by said printer.

Claim 50 - The machine of Claim 49 wherein said substrate block holders include a source of vacuum within said bed with vacuum ports extending up through said alignment locations in said bed to hold said substrate blocks down upon said alignment locations of said bed in fixed position during printing.

Claim 51 - The machine of Claim 50 wherein said substrate block holders include alignment structures upon said substrate blocks having a contour complemental with structures within said bed, such that said substrate blocks are precisely aligned upon said alignment locations of said bed when said source of vacuum applies a vacuum force drawing said substrate blocks down upon said bed.

Claim 52 - The machine of Claim 51 wherein said alignment structures include alignment pins and alignment holes of complemental form in said substrate blocks and in said bed, with said pins received within said holes when said substrate blocks are properly aligned upon said bed.

Claim 53 - The machine of Claim 48 wherein said machine includes a means for moving said substrate blocks between said alignment locations.

Claim 54 - The machine of Claim 53 wherein said alignment locations of said bed include a rectangular array of said steps arranged in multiple rows and columns, and wherein said substrate block moving means includes a shuffler blade adapted to slide all of said substrate blocks laterally a distance similar to a width of said substrate blocks, and a spatula adapted to grab a column end of substrate blocks most distant from said shuffler blade with one of said end substrate blocks removed with a completed structure and the remainder of said end substrate blocks replaced on an end of said bed adjacent

said shuffler blade, but down one row from a previous row for each of said end substrate blocks.

Claim 55 - An apparatus for supporting a structure while it is being print formed by a printer, comprising in combination:

a substrate block having an upper surface adapted to support the structure being print formed thereon by a printer located above said upper surface;

a substrate block height controller located below said upper surface, said height controller adapted to adjust a height of said substrate block downward after each printing cycle by a distance similar to a thickness of each print layer, such that a position of a top of the structure being formed remains constant relative to the printer.

Claim 56 - The apparatus of Claim 55 wherein said height controller includes a bed having a plurality of steps at different heights having a height differential similar to a thickness of each print layer, and a means for moving said substrate blocks between said steps sequentially from higher steps to lower steps of said bed.

Claim 57 - The apparatus of Claim 56 wherein said bed includes a rectangular array of said steps arranged in multiple rows and columns, and wherein said substrate block moving means includes a shuffler blade adapted to slide all of said substrate blocks laterally a distance similar to a width of said substrate blocks, and a spatula adapted to grab a column of end substrate blocks most distant from said shuffler blade with one of said end substrate blocks removed with a completed structure and the remainder of said end substrate blocks replaced on an end of said bed adjacent said shuffler blade but down one row from a previous row for each of said end substrate blocks.

Claim 58 - The apparatus of Claim 56 wherein said machine further includes a plurality of substrate block holders each adapted to hold one of said substrate blocks precisely upon one of said steps of said bed during printing by the printer.

Claim 59 - The apparatus of Claim 55 wherein said height controller includes an elevator with a fixed position base and a lift of adjustable height fixed between said

base and said substrate block.

Claim 60 - The apparatus of Claim 59 wherein said lift is adapted to shorten between each print cycle by a height similar to a thickness of each print layer.

Claim 61 - A method for high volume print-forming of structures, including the steps of:

identifying a pattern of each layer of a structure to be formed;

encoding a printer with image data corresponding with the pattern of each layer, the printer adapted to print material from which the structures are to be formed;

locating a bed having a plurality of alignment locations below the printer, the alignment locations having different heights;

positioning movable substrate blocks on the alignment locations of the bed;

printing the material down toward the substrate blocks to deposit a layer of the print material;

moving each substrate block to a next lower alignment location on the bed with a substrate block on the lowest alignment location removed; and

repeating said printing step and said moving step to form additional structures.

Claim 62 - The method of Claim 61 wherein the image data encoded into the printer remains unchanged as the structures are provided.

Claim 63 - The method of Claim 61 including the further step of matching the number of alignment locations on the bed with the number of layers in the structure to be formed.

Claim 64 - The method of Claim 61 including the further step of sizing a height differential between each of the alignment locations of the bed equal to a thickness of a layer of the printed material.

Claim 65 - The method of Claim 61 wherein said printing step includes the steps of separately printing a positive layer with a first material and a negative layer with a second material, the positive layer and the negative layer occupying the same elevation,

with later removal of the negative second material applied during said printing step.

Claim 66 - The method of Claim 61 wherein said printing step includes the step of providing a screen printer with multiple separate spaces equal to the number of layers in the structure to be formed, with each space provided with a pattern corresponding with a geometry of one of the layers of the structure to be formed.

Claim 67 - The method of Claim 61 wherein said moving step includes the step of moving the substrate blocks in a pattern along a plurality of linear rows and linear columns of alignment locations in the form of steps in the bed with each moving cycle involving shifting along a common row to an adjacent column except that end substrate blocks at the end of each row in the direction of movement is moved to the opposite end of the bed and down one row, and with the end substrate block at an end of the last row being removed with a completed structure thereon, and with a new substrate block supplied at a first row of the bed ready to begin print-forming thereon.

Claim 68 - The method of Claim 61 wherein the moving step includes the step of moving the substrate blocks upon a rectangular array of multiple columns and rows of the alignment locations in the form of steps with adjacent rows of substrate blocks moving in opposite directions, and with substrate blocks at the end of each row moving to an adjacent row within a common column, and with one substrate block in a last row having a completed structure thereon removed, and with one substrate block in a first row newly provided for beginning the print-forming process thereon.

Claim 69 - The method of Claim 61 wherein the moving step includes the step of moving the substrate blocks along a moving pattern that spirals between a perimeter of the bed and a center of the bed.

Claim 70 - The method of Claim 61 wherein the moving step includes the step of moving the substrate blocks along a linear path.